CHAPTER III:
(i) Mughal views on Science and rationalism
(ii) Mughal response to European technology and nature of response
Mughal views on science and rationalism

Mughal perception of European science and technology was crucially determined by the Islamic heritage. The Mughal understanding of scientific thought was based on the influence of Hellenic and Hellenistic thought in the Islamic civilization. In the Muslim world, the growing influence of the Mutazalites, the Qadarites, and several other schools of rational thought, had helped create conditions for the favourable reception of Greek thought among the Muslim intellectuals and educated elites. Of course the role of Abbasid state was hugely significant, for without their patronage, Hellenic and Hellenistic ideas would scarcely have gained ground in the Islamic world.

Within Islam, there were two schools with respect to Greek learning. The first was the Hermetic-Pythagorean school. It was metaphysical in approach, based on divine rather than human knowledge. It became an influential component of Islamic philosophy, much more than the second school i.e. the syllogistic-rationalistic school of the followers of Aristotle (which remained secondary). Some of the former’s cosmological beliefs were integrated into Sufism. It also influenced the Ismailis who believed that ‘receiving information’ from a learned and credible informant alone was knowledge, and placed divine knowledge, above human intellect and reason. While in the Islamic world, Pythagoreanism led to metaphysical thought, in Europe it conveyed a vision of a harmonious geometric universe e.g. Copernicus.

The other component of Islamic thought was the ‘atomistic’ school of thought which flourished in tenth century, which was represented by the Ash’arites (who denied the Aristotelian notion
of causality and believed in strict consequentiality).

Apart from these, there were two other schools professing to follow the Greek philosophers. One was the Peripatetic school, whose doctrines were a combination of the ideas of Aristotle and of some Neoplatonists. Their approach was philosophical rather than metaphysical. While their thought was the bedrock of the scientific revolution in 16th and 17th centuries in Europe, it remained a secondary aspect of Muslim intellectual life. Great figures of Arab science such as Al-Kindi, Averroes (Ibn Rushd), al-Razi (Rhazes), Ibn Sina (Avicenna) and al-Beruni were some of the representatives of this school.

The other school which was more sympathetic to the Pythagorean-Platonic school than to Aristotelian tradition was later called Ishraqi (Illuminatist) school. Its literature was primarily symbolic, in which they would see ‘signs’ in nature’s phenomena, as a guide to the final ‘illumination.’ Its enigmatic approach later attracted many Sufis who took up its ideas. The former school was strong during the tenth and eleventh centuries after which their influence weakened. In comparison, the Ishraqi creed became stronger after twelfth century, mainly under Al Ghazali’s influence.

The growth of rationalism suffered a setback in the eleventh century, when works as Qabus Nama and Siyasat Nama of Nizam-ul-mulk Tusi were written. In these works, Socrates, Plato and Aristotle were admitted to the status of Islamic sages, and came to be uncritically appropriated in the Islamic world. Despite the fact that Tusi ascribed romances and parables to the Greek philosophers, such as Plato and Aristotle enhancing their reputation among Muslims, their philosophic heritage was never integrated into the body-politic of orthodox Sunni or Shi'i Islam. The remark
of celebrated mystic Ibn al 'Arabi (1165-1240) that 'religion is based on the law of Mohammad, whereas the philosophers' trend of thought follows Hermetic traditions, clearly delineates the difference between the two branches of thought.'

Islamic interest in technology seems to have reached its apex with al-Jazari (1204-6). Before Jazari, Ibn 'Ali Sina (Avicenna, d. 1037), Al beruni (d. 1030) and Ibn Rushd (Averroes, d. 1198) were the greatest representatives of the Muslim interest in science. But post-Al Jazari science received a setback throughout the Islamic world.

In the 12th century, there was a heavy onslaught on reason (ma'qulat) and philosophy (falsafa), in which Ghazali (d. 1111) played an important part. He counteracted the influence of Avicenna and his followers, and he wrote "Tahafut al-Falasifa" (The incoherence of the philosophers) in which he strongly refuted their belief in the eternity of the world and their views on the nature of God. He denounced the Muslim followers of Socrates, Plato and Aristotle as unbelievers. He concluded his work with the remark that philosophers were guilty of infidelity. Al-Ghazali in a way paved the way for the theological victory of Asha'ri determinism (which denied any connection between cause and effect, and therefore held that any kind of prediction is impossible), over Muta'zali rationalism. He repeatedly argued the scientific

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1 S.A.A. Rizvi, Religious and intellectual History of the Muslims in Akbar’s Reign, N. Delhi, 1975, p.10.
rationalism was the belief that materialism as well as disciplines of mathematics, natural science and medicine could all lead to unbelief and atheism. Al-Razi, Abul Barkat and Al-Amidi also carried on a severely damaging attack on Greek philosophy.

The growing influence of Sufism also caused a setback to development of scientific and rational thinking. It stressed on intense religious consciousness and suggested that logic and reasoning were futile for a fulfilling spiritual life. The philosophy of Shaikh Shihabu'd Din Suhrawardy Maqtul (1155-1191) known as *Hikmat-ul-Ishraq* (philosophy of illumination) sought to integrate Platonic and Aristotelian philosophy with Hermetic ideas and placed 'the whole structure within the context of Sufism,' thereby blurring the distinction between Sufism and philosophy (*falsafa*).

There were contradictory trends, as well, and some rulers of the Sultanate period, especially Mohammad Bin Tughlaq and Firoz Shah Tughlaq made serious efforts for the promotion of rational thought.\(^6\) Barani persistently condemned the *falsafa* (he has written against philosophers such as Najm Intishar, Sa'd and Maulana 'Alimu'd Din, some of whom were patronized by the earlier reigns of the Sultans of Delhi\(^7\) in particular the Avicennians\(^8\) and showed contempt towards the Mutazilites.

\(^5\) Ishraqi philosophy is expressed in *Kitab Hikmat-al Ishraq* (the philosophy of illumination) and other works. For the essential facts of Shihabuddin's life, see *An encyclopedia of Islam*, vol. IV, pp.119-20. For an insightful short interpretation, see Roy Mottahedeh, *The Mantle of the Prophet Religion and Politics in Iran*, New York, 1985, p. 149.
\(^7\) S.A.A. Rizvi, *Religious and intellectual History of the Muslims in Akbar's Reign*, p.12.
\(^8\) Barani, *Tarikh-i-Firozshahi*, p. 35.
According to him, the influence of philosophers made Sultan ruthless, cruel and irreligious. Paradoxically, his writings (such as *Fatawa-i-Jahandari* and *Tarikh-i-Firozshahi*) were at the same time, not devoid of reason, and he even quoted from Aristotle and Plato’s writings. However, as Professor Irfan Habib argued that he offers a case ‘where the subterranean persistence of rationalism through the continued survival of philosophy reasserted itself in an indirect manner, while the ever changing patterns of the historical process forced a fresh examination of received notions. But Barani had no successor and if anything the resources of reason that he was still able to invoke seem to have dwindled after him.’

By the time the Mughals established their rule in India, science and rationalism had been marginalized from intellectual life. Abu'l Fazl, the principal ideologue of Akbar's period, at the end of the 16th century was to mourn "the blowing of the heavy wind of taqlid (tradition), and the dimming of the lamp of wisdom. The door of "how" and "why" has been closed; and questioning and enquiry have been fruitless and tantamount to paganism." He probably stands out in the effort to develop rational sciences in India. He emphasized his respect for the Hellenistic sciences and favourably cited the works of classical Islamic rational philosophers. He even suggested that the absence of the spirit of *sulh-i kul* (peace with all) in India was caused mainly by the preponderance of an attitude of imitation (taqlid) and by the suppression of intellect and reason. Abul Fazl severely criticized al-Ghazali for condemning sciences that were not manifestly based

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9 *ibid.*, p.467.  
10 Irfan Habib, *Reason and Science in Medieval India*, p. 166.  
11 *ibid.*, Aín-i-Akbari, vol. iii, p.3.  
12 *ibid.*, pp.3-4.
upon the Quran. His monumental work \textit{Ain-i-Akbari} is written within a rational and scientific frame of reference. In the book, he even discusses the theories on the propagation of sound, light, specific gravity. An evaluation of these theories reveals the persistent influence of Aristotelian philosophy on Mughal rationalism.

In the early seventies, Abul Fazl along with his father Shaikh Mubarak and his brother, Faizi, were the among the most prominent people who introduced Emperor Akbar to an Islamized version of Greek Philosophy. Akbar was so charmed by their philosophical discourses (\textit{sukhnan-i-hikmat}), so strongly disapproved by post-Ghazali Islamic theology and found them so enchanting that he ‘found it difficult to keep away from them.’ However, the apparent revival of science at Akbar's court was not backed or reinforced by any general system or systems of rational philosophy. Even Shaikh Mubarak who had introduced Akbar to Greek philosophy is said to have been greatly inclined to the Ishrafi creed of Shihabuddin Suhrawardi Maqtul. As Prof. Irfan Habib opined, the tolerance of science at Akbar’s court stemmed not so much from a belief in reason as from a belief in Pantheism (the doctrines of Ibn al-Arabi (d.1240) had reached India around 1400 A.D.), which taught one to respect diversity. However, pantheism which had in the sixteenth century provided an umbrella for the revival of classical science became, in the seventeenth, a

\begin{itemize}
\item \textbf{13} Muhammad Hashim Kishmi, \textit{Zubdat-al-Maqamat, Lucknow,} A.H. 1302, p. 131.
\item \textbf{14} Abul Fazl, \textit{Ain-Akbari,} vol iii, pp. 182-3.
\item \textbf{15} Irfan Habib, \textit{Capacity of Change in the technology of Mughal India,} Seminar on ‘Technology in Medieval India Century,’ September, 1984, BITM,Calcutta, p.25.
\item \textbf{16} S.A.A. Rizvi, \textit{Religious and intellectual History of the Muslims in Akbar's Reign,} p.80.
\end{itemize}
source for the rejection of science and revival of religion. In the sixteenth century, the Mahdavi movement had attained considerable success: and it was certainly a consciously 'revisionist' doctrine.

The Mughal elites were aware of the atomistic philosophy of Leucippos and Democritos, for their works had been translated into Arabic by early Arab scholars such as al-Kindi. However a new interpretation of this idea suddenly acquired prominence as a result of the translation provided by Fr. Bernier of the works of Pierre Gassendi (1592-1655). The attempts by Gassendi to reconcile mechanistic atomism with Christian belief in immortality, free will and the existence of an infinite God and therefore infinite creation were taken up by the man who was to assume immense importance in the eighteenth century, as the author of the syllabus for the students of the Dars-i-Nizamiya, namely Qazi Muhibullah Bihari. Bihari's treatise on the Djuz la yatadjuzza meaning an indivisible particle was completed just a few years after the works of Gassendi had been circulated by Bernier and Danishmand Khan among the Mughal elites and ruling classes. Muhibullah Bihari also went on to write his Risala (treatise) on time, and on motion-both of which became standard textbooks for the students of Shaikh Qutbuddin Sahalvi, whose son Nizamuddin went on to devise the new syllabus called Dars-i-Nizamia, followed as the curriculum in the Firangi Mahal. The emphasis on Greek logic and reasoning in the Dars-i-Nizamia led several mullahs of Awadh and Delhi to denounce it as being anti-

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17 Irfan Habib, Reason and Science in Medieval India, 1996, p. 171.
private curriculum of Shah Waliullah (1702-1762) was relatively wider in scope and included some amount of mathematics, astronomy, and medicine. But himself a chishti sufi of Delhi, he also rejected the rational sciences. The important point that is often not realized is that the dars-i-Nizami, which became the standard curriculum for most madrasas in the Mughal period, was influenced by the European intellectual contacts with the Mughal elites. It was after all owing to the influence of Bernier that Gassendi's ideas found favourable reception in the curriculum of the period. It is also important to realize that the Mughal intellectual engagement with such Europeans as Bernier shaped the reception of Greek thought. While Greek falsafa remained important in the madarasa education, it had been modified, in bits and pieces, by the creative engagement of the Europeans with the Mughal intellectual class.

Under Mutazilite Caliphs in Baghdad the adoption of rationalism led to the flourishing of the sciences through the Islamic academy of science "Bayet al-Hikma." In the seventh century, physicians made great contributions and were the pioneers of medicine in the Arabic society. Translations were made of books on medicine from foreign languages, even officially, into Arabic. Hunain b. Ishaq (194-264 A.H.) officially translated books of Hippocrates and Galen, and wrote down many medical books among which is his famous one on Ophthalmology was called Al Ashr Maqalat fi al-'Ayn, which is considered to be the first scientific attempt towards Ophthalmology.

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Like other subjects, the medical science at Mughal court was also under overwhelming influence of Greek medicine called Unani tibb, into which were also incorporated the achievements of Arab scientists. Fathullah Shirazi, an Iranian scientist at Akbar's court, was also a follower of Greek legacy. He translated the famous *Qanun* of Abu Ali Sina (Avicenna) into Persian. Later commentaries on Ibn Sina’s *Qanun* were written, e.g. by one Hakim Ali Gilani entitled *Sharh-i-Qanun-i-Ibn Sina* in 5 volumes, Shaikh Ahmad Qunnuji’s (c.1700) *Tuhfat-ul Atibba* etc. to count only a few.

The Mughal elites were reluctant in trying anything which was not prescribed by the Greeco-Arab authoritative texts. In 1603, for example, a discussion was held on the use of tobacco. In this year Asad Beg Qazwini brought to the court from Bijapur a small sample of tobacco and a smoking pipe for the emperor. When Akbar showed an inclination to smoke, he was sought to be dissuaded by Hakim Ali Gilani, who argued that as nothing was mentioned regarding tobacco in ‘our medical books’, it would be risky to use it without making further investigations. While one may not disapprove in principle of the advice that Hakim Ali Gilani gave on the occasion, one cannot help noting the basis of the hakim’s argument. For him nothing was permissible that was not sanctioned by the texts of unani tibb handed down by the great masters of earlier times. This obviously applied to the new ideas

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23 Asad Beg, *Ahwal-i Asad Beg Qazwini*, MS. BM. OR. 1996 (Rotograph in Department of History, Aligarh Muslim University), ff. 36-37.
regarding medicine that were coming at this time from the West. Asad Beg says that when he brought tobacco from Bijapur, the Emperor tried it, but Gilani dissuaded him. Asad Beg said that Europeans are not so foolish as not to know about it. There are wise men among them who seldom err or commit mistakes, for which the physician representative said that 'we do not want to follow Europeans and adopt a custom which is not sanctioned by our wise men without trial.' After considerable reluctance, tobacco came to be used as medicine. However, this was only an exception, and we do not find similar examples during the rest of the Mughal period. Akbar allegedly approved of a scheme for building a hospital and initiating what would be called a 'medical mission.' This, perhaps, did not materialize, for nothing about it is mentioned in either Jesuit accounts, or Mughal chronicles.

The Indian physicians or hakims were apparently unaware of European advances in medical science. This is borne out from the accounts left behind by European travelers. This was despite the

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27 Manucci firmly believed that 'tabibs had no knowledge of medicine and were certainly not in a position to cure the stone, paralysis, epilepsy, dropsy, anaemia, malignant fevers or other difficult complaints. (Niccolao Manucci, *Storia Do Mogor*, 1656-1712, vol. ii, p. 333.). Commenting on the level of medical education in India, Fryer suggests that the field of medical science in India was 'open to all Pretenders, here being no Bars of Authority, or formal Graduation, Examination or Proof of their Proficiency; but every one ventures, and every one suffers; and those that are most skilled, have it by Tradition, or former Experience descending in their Families.' (John Fryer, *A New Account of Fast India and Persia in Eight Letters being Nine Years Travels Begun 1672 and Finished 1681*, Delhi, 1985, p. 114). Fryer further observed that the Indian physicians neither understood the
fact that by the seventeenth century European physicians and surgeons had established a reputation in Mughal India and were much sought after by the Mughal elites, including the kings. The Mughal rulers even allowed them to treat the female members of the royal household. Hawkins, e.g. treated Jahangir's daughter. In 1658, when Aurangzeb came to the throne, Francois Bernier was appointed court physician.

Even so, the Mughal intellectual class did interact with the Europeans in exchanging ideas about science. One cannot be sure of the extent of dissemination of European scientific ideas in Mughal society, but they did engage with them to better comprehend the western scientific thought. Bernier gave lessons on anatomy and on circulation of blood propounded by William Harvey (1578-1657) to his patron in India, Danishmand Khan. Bernier even dissected sheep to explain to his host the concept of circulation, but failed to impress him. Danishmand Khan retained the Galenic and Avicennean views of the Indian hakims. While evidence of such intellectual engagement is scarce, the case of Danishmand Khan strongly suggests the barriers to the reception of European science were still surmountable.

Even as a certain degree of reluctance in the acceptance of European science is fairly evident, there was still a continuous reception of European science in the Mughal society. Father Busi, (who often held academic discussions with Dara, Aurangzeb's pulse nor did they treat other ailments. (ibid., pp. 114-15). Careri goes still further when he says, 'In Physick they have but small skill, and cure several diseases by Fasting', (Careri, Indian Travels of Thevenot and Careri, edited by Surendranath Sen, New Delhi, 1949, p. 247) and Manucci is much harsher when he exclaims, 'From such doctors and such drugs libera nos Domine' (Niccolao Manucci, Storia Do Mogor, Vol. iii, Pt. iii, Calcutta, 1966, p. 214. 28 Jauhar Aftabchi, Tazkira-ul-Waqiat, pp.168.
brother) reportedly taught Mathematics to a 'prince of Blood who was superintendent of the nobility'. The discussion between Amanat Khan, the Governor of Surat (1690), and Manucci, the Italian traveller, on alchemy being practiced by the former is another instance of the same type. In 1658, when Aurangzeb came to the throne, Francois Bernier was appointed court physician (and his Indian host Mulla Shafi Yazdi alias Danishmand Khan was exempted from personal appearance at Aurangzeb's court. This was done in order to enable an uninterrupted translation of the European texts in Bernier's possession and exchanges of ideas between the two). Bernier held discussions with him on philosophical and scientific matters which included astronomy, geography and anatomy. He also explained to Danishmand Khan the essence of the Cartesian worldview that had captured the imagination of the seventeenth century European philosophers. With skepticism as its guiding principle, European science would not have gone down well with the ulema and the orthodox classes. Bernier translated the works of European philosophers, Gassendi and Descartes, into Persian for his patron and discussed with him the discoveries of Harvey and Pecquet on anatomy and physiology.

Despite these creative, if still limited engagements, the intellectual base of knowledge still remained the Graeco-Arab learning. The Graeco-Arab learning came to be venerated by the Mughal scholars, and there was, despite European contacts, no effort to transcend it.

The fascination with Greek and Latin languages was retained down to the eighteenth century. When a noble of Aurangzeb, Mutamad Khan Rustam bin Diyanat Khan Qubad Harisi Badakhshi, a Diwan in Deccan, visited Europe \((\text{Firangistan})\) perhaps towards the end of the seventeenth century, he only laboured to acquaint himself with Greek and Latin sciences \((\text{ulum latini u Yunani})\) during his long visit.\(^{33}\)

To conclude, the ruling elites retained the Arabic-Hellenistic thought, and European scientific thought could never pose a challenge to that thought. Indeed in Akbar’s reign, Mutazalite philosophy gained some prominence in the elite circles, but it was successfully challenged by alternative philosophies, like those of the Ishraqi and pantheistic philosophers. Besides, the Aristotelian philosophy, which had been discarded by the Europeans, was held on by the so-called ‘rationalists’ to the point that it stifled free and critical enquiry. The Mughal intellectual did engage and interact with European scientific thought, but under the suffocating clutches of Graeco-Arab learning, failed to make that interaction a productive one.

Mughal Response to European Technology and Nature of Response

In the Islamic empires of the East, European ‘rarities’ or ‘curiosities’ were collected and gifted by the elite. Humayun wrote about an embassy sent by ‘the sovereign of Rum, Soleyman the Magnificent to Persia and exchange of ‘various valuable and curious articles: such as, instruments and vessels inlaid with the gold and precious stones, daggers, scimitars, cloths of different kinds, and rarities from the several countries of Europe.’ In Kabul, the (interim) capital of the empire (in that year), the palace and its gardens were elaborately decorated during the great Mystic Feast celebrated soon after Humayun’s accession in 1530. Turkish and European cloths decorated the walls of rooms that were reportedly “the envy of Chinese picture galleries.”

When the direct contact was established between the Portuguese in Goa and the Mughals during the period of Akbar, European wares were demanded by the Mughal elite and European objects of luxury were eagerly bought from Portuguese. In one of the documents presumably belonging to the early seventeenth century, there is a reference to the Mughal court placing an order

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3 *Nobility under the great Mughals*, Z.A. Desai (based on *Zakhirat-ul-Khawanin*), Delhi, 2003; in 1616, Francis Fetiplace wrote to EIC, that European velvets were brought here in past by the Portugals; *Letter Received*, vol. iv, p.243.
for horses, canopy and curtains from the Portuguese. The articles imported from Europe were chiefly broadcloth; musical instruments, as trumpets; pictures; curiosities.

Jahangir displayed as much interest in European ‘curiosities’ as Akbar which he too would acquire from Portuguese in Goa. Muqarrab Khan, a high placed noble under Jahangir, was once sent to Goa for a number of purposes, including the collection of novelties. Jahangir sent yet another officer, Nadir Zaman, for the same purpose.

During his period, the interaction with the English also advanced further. Muqarrab Khan, his noble, was curious about European technology. In 1612, he asked the English factors to provide him a model of a 'Chain-Pump', (which was used in ships to bail out water) which, it seems, was presented to him. Roe also reported that he sent for the Governor of Surat ‘six faire knives’ which he is said to have accepted gratefully.

When Jahangir gave the title of Shah to Khurram (who was now called Shah Sultan Khurram), he presented him ‘a carriage according to English fashion.’

The gifts were received as novelties, and even if they technological expertise the Mughals showed no interest in manufacturing them. Roe also observed that ‘the king desireth

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4 Bibliotheque Nationale, Suppl. Pers. 482, H. 27 (a). I have consulted the microfilm copy of the manuscripts available at the Centre of Advanced Study in History, (Aligarh).
6 Tuzuk-i-Jahangiri, pp.215,234.
7 Caesar de Federici, Extracts of his.... eighteen years Indian Observations 1563-1581, Purchas His Pilgrims, 10, Glasgow, 1905, vol.iii, pp. 263-4.
9 Tuzuk-i-Jahangiri, p.338.
unheard of and rare things but such as either rich or full of cunning, 
good art and work, which he can as well discern from bad as we 
ourselves and careth as little for things of mean value.'¹⁰ Factors 
write that 'he affects not the value of anything but rarity in 
everything.'¹¹ Jahangir's interest in such gifts did not go beyond 
mere curiosity and failed to inculcate in him an interest in the 
technological or scientific principle involved. In 1616, for example, 
when Roe gave a small silver watch to prince, he said that he 
would much prefer the pictures that he had shown to the King.¹² 

There were some items which were received from the 
Europeans mainly as gifts. During the seventeenth century, 
telescopes were used for astronomical observations and as a 
navigational aid by European seamen. (European pilots engaged by 
Indians must have been using the telescope for navigational 
purposes. It was also by them used to 'spy' enemy ships.¹³ The first 
clear documented evidence of its knowledge to Mughals comes 
from the reign of Jahangir when Sir Thomas Roe presented 
'burning glasses and prospectives' (i.e. telescopes) to the 
Emperor.¹⁴ Asaf Khan, brother of Nur Jahan, is also reported to 
have taken interest in telescopes (durbin) along with spectacles and 
other such European devices.¹⁵ In 1652, the English factors asked 
the Company to send them, among other things, telescopes as

¹¹ *Letter Received*, vol.i, p.33. 
¹⁵ *A Supplementary Calendar of Documents in the India Office Relating to India or to the Home Affairs of the East India Company, 1600-1640*, ed. W. Foster, p.83.
presents for Indians.\textsuperscript{16} We are told by the English in 1652 that ‘little sale’ could be expected of such things.\textsuperscript{17} They write that in Agra, among other things, spectacles and burning glasses were unvendible ‘by reason of king’s absence.’\textsuperscript{18} They further commented that ‘glass ware such as wine glasses, water glasses, burning glasses, prospective glasses, spectacles etc. was not esteemed.’\textsuperscript{19} However, its significance was reduced to being a mere curiosity as we may infer from the fact that in 1666, Tavemier presented a telescope to the ten-year-old son of Sha’ista Khan, the governor of Bengal.\textsuperscript{20} It is clear that even by then, its manufacture was not attempted, although the Mughals were presumably not unaware of its utility and significance. Besides, there is no evidence of its use by Indians either in the navigational or astronomical observations during the seventeenth century.\textsuperscript{21} Evidently, no productive use was made of telescopes during the high Mughal period. Raja Jai Singh Sawai (1699-1743) of Jaipur, a Hindu vassal of Muhammad Shah (r. 1719-48), (who had built or restored five observatories between about 1721 and 1734, including one in Delhi and one in his own capital in Jaipur)\textsuperscript{22} did perhaps use telescopes at the Delhi observatory.\textsuperscript{23} But these telescopes were presumably bought from the Jesuits and were in no case of indigenous manufacture.

\textsuperscript{17} \textit{ibid}.
\textsuperscript{18} \textit{Letter Received}, vi, p.201.
\textsuperscript{19} \textit{Letter Received}, vol.iv, p.298 (appendix).
\textsuperscript{20} Tavemier, Jean Baptiste \textit{Travels in India, 1640-67}, vol.i, p. 130.
\textsuperscript{22} \textit{ibid}.
Terrestrial globe was another item which was given as a present to the Mughal Emperors, princes and nobles by the English Factors. Terrestrial globes were used by Europeans aboard ships during the seventeenth century. Globes appear as a symbol in a painting during the reign of Jahangir, showing an outline map of some Asian countries. But it remained just that- a curiosity and a symbol used in allegorical paintings. Apparently, its practical use was largely ignored by the Mughal elite.

Similarly, compasses were neither much used, nor eagerly procured, and obviously, not manufactured. In 1677, the English factors in Bombay complained that, among other things, compasses were not procurable and they requested the Company to send them from England. They thought that, apart from their own use, surplus compasses with them might also be sold (to Indians) with profit. It could be perhaps inferred from, this that Indians did not manufacture compass themselves. We find ourselves similarly situated as regards binnacles, lanterns etc.

29 In 1668, the English factors on the Coromandel coast required lanterns from England. See Foster, W. (ed.) *The English Factories in India*, 1668-9, P.68; Also see Irfan Habib, *The Technology and
Sand or hour-glasses were brought by Europeans to India. This time-indicating device came into use in Europe during the second half of the fourteenth century. There is little indication of its use in India before Akbar's time. They were perhaps not much used for time-keeping purpose but seem to have been readily accepted and used for astronomical or astrological purposes. Some Mughal paintings, while depicting a birth scene in harem, show astrologers casting the horoscope with a sand-glass. These were used as a symbol in Mughal paintings, particularly during Jahangir's period. Again, Manucci refers to its use in the Mughal army. John Marshall (1668-72) observed: 'In some places, as at Patna, they have glasses with sand in them, made like our hour-glasses in England, which are exact gurry.' Indian ghari was of twenty-four minutes duration. In Europe, there were one hour, half-hour, and

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Economy of Mughal India', The Devraj Chanana Lectures, Delhi, 1970 (cyclostyled), p. 21.

30 Foster, W. (ed.) The English Factories in India, 1618-21, p. 21; 1646-50, p. 338. For 'half-hour' and 'half-minute' glasses, see ibid., p. 106.


32 Cf. the Akbarnama illustration, no. 80/117 (Victoria and Albert Museum): 'Birth of a Prince'; also, an illustration from Akbarnama (vol. i, BM), f. 34b: 'Birth of Timur,' Luber Hajek, Indian Miniatures of the Moghul School, London, 1960, Pl. 18: 'Astrologer with Hour-glass, etc.'

33 For a giant hour-glass with symbolic depiction, see R. Ettinghausen, Paintings of the Sultans and Emperors of India, Pl. 14: 'Jahangir Preferring a Sufi Shaikh to Kings' (A.D. 1625).


even half-a-minute glasses in Europe, but not those of twenty-four minutes, which shows that these sand-glasses were manufactured here.

There is, however, some evidence to suggest that European technology in ship-building was borrowed by the Mughals. Muqarrab Khan, in-charge of the ports of Surat and Cambay during Jahangir's reign, who asked the English to provide him with a model of a "chain-pump", which may have been supplied to him. That European ships were emulated is evident from the fact that as early as 1612, the ships at Dabul are reported to have been made 'Christian like, with topps and all their tackleinge accordingly.' It was remarked by the end of the first half of the seventeenth century that Indians had become so expert as to convert an Indian-built ship outwardly 'after the Christian manner' by fitting her properly. During the 1670-3, Bowrey, Fryer and Ovington praise the Indian ship carpenters. From about the middle of the 17th century, Indian ship-builders at Surat also began to copy closely the Dutch and English designs of ships, and the results were eminently successful. Nevertheless, neither any European machine, nor apparatus is known to have been used in that industry. Apparently

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40 EFI, 1642-5, p.168.
42 ibid., p. 267.
the carpenters and others went on working with their existing tools. The imitation of the European ships did not lead to any technological development. The European ships were fitted with pumps to bail out water. They used piston-pumps before the opening of the sixteenth century, but shifted to (iron) chain-pumps. The reason for the shift to chain-pumps was that it 'takes up twice as much water as the ordinary did' European account hints at the use of buckets by which the passengers cleared water manually.

These pumps did arouse the curiosity of Indian shipwrights and indeed the Indians ships had started using chain-pumps from around the middle of the seventeenth century. In 1656, Tavernier testifies their presence in a large vessel belonging to the King of Golkonda, in which he travelled from Masulipatam to Gombroon (Bandar Abbas), piloted by six Dutch seamen and assisted by one hundred Indian sailors.

In 1647, more than a century after the Europeans came to India, a ship of 'European build bought for Prince Dara Shukoh was later rejected 'for being major part caulked and not rabited, which building is only known to these people.' Contemporary observers however, do not speak of any technical superiority of caulking over the Indian method of performing the same task.

45 ibid., p. 667, n. (a).
46 Qaisar, A. J. 'Merchant Shipping in India during the Seventeenth Century', p. 197, n. 5.
47 Tavernier, Jean Baptiste Travels in India, 1640-67, p.255.
48 EFI, 1646-50, pp.90-91.
That no active interest was taken by Mughal elite in technological
development is evident from the fact that there was no attempt to
manufacture the pumps and its technology was not copied and the
pumps continued to be either borrowed or purchased from
Europeans.

Several European goods did indeed have a good demand
among the Mughal aristocracy. During the sixteenth century, it
appears that a variety of glass objects were imported largely from
Europe by the Portuguese,^ but it is during the seventeenth century
that one meets with considerable documentation of European
glassware imported into India which included looking-glasses,
window-panes, spectacles, telescopes, burning and 'multiplying'
glasses, sand or hourglasses, etc. as there was some demand
generated by the Mughal elite. Muqarrab Khan had even wanted to
'experience the use of window panes, a wish which unfortunately
could not be fulfilled by the English factors due to the non­
availability of a glacier. In 1616, Joseph Salbank wrote to EIC
from Agra that Looking glasses could only be given away as a
present. In Dec.1617, Francis Fetiplace and Robert Hughes to
EIC that English looking glasses are (heavy and bad and therefore)
unvendible. In any case, they write that glass ware such as wine
glasses, water glasses, burning glasses, prospective glasses,

^9 P.K.Gode, 'History of Glass etc.', p. 87; cf. A.J. Qaiser, Indian
Response to European Technology and Culture p.71. In Europe in
the early sixteenth century, tin-foil metallic mirrors were replaced
with the looking-glasses of Venice (an extension of the knowledge
of making sheet and plate glass) which pushed aside metallic
mirrors.( Cf. Honey, W.B. Glass-A Handbook and Guide to the
Museum Collection (Victoria and Albert Museum), (London,
^10 EFI, 1618-21, p.11.
^11 Letter Received, vi, p.232.
^12 Letter Received, vi, p.244.
spectacles etc. was not esteemed. President Breton and co. at Swally Marine wrote to the company to send as gift to Dara, a cabinet and looking glasses. In the later stages Indian workmen had also adopted European skill in making looking-glasses, spectacles and window-panes of different colours, but we certainly do not find any reference of its manufacture during Mughal period.

In India, metallic mirrors were used and hence European looking-glasses were acquired as a novelty by the Indian elite either through purchase or gift from Europeans. As early as 1608, William Finch saw a few large Venetian mirrors placed one above the other on the walls of Emperor Jahangir's court at Lahore, which may have been acquired from the Portuguese at Goa. The nobles also showed interest in acquiring looking glasses. Asaf Khan, for example, is reported to have bought looking-glasses from an Italian in 1615 who had gone to Jahangir's court at Ajmer with looking-glasses where 'he sold some wares to Asaf Khan, a great Mughal noble.' In 1615, Roe writes that no one will accept spoiled things, as your guilded looking glasses, unglued, unfoyled, and fallen peeices (and here no man taught how to mend them).

53 ibid., iv, p.298 (appendix).
54 EFI,1642-5, p.160.
57 Letter Received, vol. ii, p. 143; Foster, W. A Supplementary Calendar of Documents in the India Office relating to India or to the Home Affairs of the East India Company, 1600-1640, p. 83.
In 1609, Laus Deo in Surat wrote that, 'I suppose that some faire large looking glass would be highly accepted of this king, for he affects not the value of anything but rarity in everything.' They write about Agra that it was a mean place—where comb cases, spectacles and burning glasses and cony skins were unvendible by reason of king’s absence. In any case, they write that glass ware such as wine glasses, water glasses, burning glasses, prospective glasses, spectacles etc. was not esteemed. Looking glasses, pictures, comb-cases and spectacles are not mercantile wares but were purchased only to give away as presents. In 1621, Muqarrab Khan purchased a large Venetian mirror (these were very costly during this period, ranging from 300 to 1,250 rupees) at a very high price, that is, 300 rupees. However, no attempt seems to have been made to learn the manufacture of looking glass. There is a reference of a certain Robert Young, who was sent to Surat by Company in 1614 in order to instruct four or five English factors in this art, but there is no reference of this man or any other person skilled in the art of making looking glasses ever visiting the Mughal court.

In 1683, another looking glass was given to Mir Bahr at Patna (which costed two rupees). Yet another was given to one of

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59 Letter Received, p.i,p.33.
60 ibid., vi, p.201.
61 ibid.,iv, p.298 (appendix).
62 ibid, p.232.
63 ibid., p.246.
64 Foster, W. A Supplementary Calendar of Documents in the India Office relating to India or to the Home Affairs of the East India Company, 1600-1640, p. 41.
65 Mir Bahr was the Lord of Admiralty. His duties were to maintain a fleet for fighting, and to police the principal inland waterways. He also looked after and regulated the sea and river ports and collected tolls from the merchants.
the subordinates of the Nawab's diwan (whose cost was three rupees).\(^6\) One was given to the amil of the Patna mint's darogha, which was valued at four rupees.\(^6\) It can be reasonably said that despite the increasing demand and use of the European looking-glass by the Mughal elite, there is no indication of its manufacture either with or without the instigation of the elite. Besides, it is equally curious that despite increasing use of looking glasses by Mughal elite, there is not a single pictorial depiction of it in Mughal paintings during the seventeenth century, and it is only in the paintings of the following century that we find the depiction of European rectangular looking-glasses.\(^6\)

Spectacles were invented in Europe in the thirteenth century, first with convex lenses, and then with concave lenses in the sixteenth century.\(^7\) The earliest reference to the use of spectacles in India is in context of a Vijaynagar minister, when in c. 1520, Vyasaraya is described as reading a book with the help of spectacles (convex eye glasses). These were perhaps gifted by the

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\(^6\) Foster, W. *A Supplementary Calendar of Documents*, 3 Sept. 1683.
\(^7\) ibid., 24 Sept. 1683.
\(^9\) Cf. Hajek, *Miniatures from the East*, Pl. 23: 'Bilawal ragini' (Rajasthan, 1750); R. Reiff, *Indian Miniatures*, Pl. 4: 'Toilette of Radha' (Kangra, 1800); *Diwan-i Hafiz* (BM Add. 7763), f. 16b (Kashmir, eighteenth century); Artibus Asiae, Supplementum xxxii, fig. 94: 'Ram Singh II of Kola Watching a Bather' (Kota, c. 1828). A miniature from Rajasthan (Reiff, Pl. 3: 'Bilawal ragini') showing the rectangular looking-glass has been dated as 'second half of the seventeenth century'. The dating seems to be doubtful: perhaps it should belong to the early eighteenth century. cf. A.J. Qaiser, *Indian Response to European Technology and Culture*, p.74.

Portuguese. During the Mughal period, we see spectacles appear in miniatures of Akbar's time. Rudolfus, a member of the first Jesuit mission at Akbar's court in 1580, is said to have used spectacles. Initially, there was less demand for spectacles. In 1616, the English factors at Surat sent a large stock of glassware, including spectacles, for sale at the Mughal court in Ajmer, but they write that 'spectacles was not esteemed.' However, they continued to procure spectacles from the European merchants. President Kerridge at Surat to John Bangham at the Mughal court, 8 September 1625, wrote: 'Mr. Young has stated that Asaf Khan (Nur Jahan's brother) desires some English spectacles; so a box containing two pairs is forwarded for him.' Later, however, the demand for spectacles somewhat grew among the elite. By mid-sixteenth-century, spectacles had become common enough to be used by Mughal painters. We get a portrait of Mir Musavvir (1565-70) shown using spectacles, signed by Mir Saiyid Ali (now in Collection-Musee Guimet, Paris). That they were quite common by the close of the sixteenth century is evident from the fact that contemporary intellectuals were exchanging letters and verses that referred to the 'ainak' in rather familiar terms. The next reference to spectacles is found in Jamaluddin Inju's *Farhang-i-Jahangiri* (1608-09), wherein 'the chashmak is a word that is said to have

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73 Monserrate, Fr. A. *Commentary on his Journey to the Court of Akbar*, p. 193.
74 Foster, W. *A Supplementary Calendar*, p. 83.
75 *Letters Received*, iv, p.298 (appendix).
76 W. Foster (ed.), *EFI*, 1624-29, p. 93.
three meanings; the first being the "ainak," Tek Chand's Bahar-i 'Ajam, a dictionary completed in 1739, lists the numerous verses in which the word chashma and chashmak occur. Careri, who saw Aurangzeb in 1695 at a very old age, wrote with admiration that the Emperor could endorse petitions "with his own hands without spectacles."

However, the Mughal elite did not show any interest in adopting the European technology for manufacturing spectacles. There is evidence of some spectacles being referred to as being of European (firangi) make which probably indicates their manufacture by Indians also at this time, though on a modest scale. But it cannot be determined whether Indians had learnt the fabrication of glass for making lenses, or they worked upon glasses imported from Europe. Although the evidence for the manufacture of spectacles with glass lenses on the eve of the eighteenth century is not very strong, there are indications of positive response from the letters discussed above: after all, the manufacture of crystal lenses was not alien to Indians. In fact one may perhaps also argue that these Indian spectacles were made of crystal lenses. The failure to match Europeans glass industry by the seventeenth century had become so visible that Prince Muazzam in the reign of Aurangzeb (1659-1707) could not believe that the glass vessels

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77 Farhang-i-Jahangiri, A.D. 1608-9, Jamaluddin Husain Inju, (Lucknow, 1876). vol. i, p. 479.
79 Thevenot, Jean de The Indian Travels of Thevenot and Careri, p. 221.
from Europe were of transparent glass and not made of crystal.\textsuperscript{81} It also shows that spectacles were not made of glass. It is difficult to be sure that they were manufactured in India and not imported, for spectacles were often brought as presents from Europe for Indian notables.\textsuperscript{82} Perhaps those made of crystal could have been of indigenous manufacture.\textsuperscript{83} Spectacles figured prominently in almost all the gifts of rarities to the emperor's courtiers and eunuchs on festivals even in the second decade of the eighteenth century.\textsuperscript{84}

Another item which was brought to the Mughal court by Europeans was the mechanical clock. It is not clear as to whether it were the Portuguese or the English who introduced it to the Mughal court. Perhaps the Portuguese brought the European mechanical clock to South India during the sixteenth century.\textsuperscript{85} We may fairly infer that such clocks were used by the Portuguese in their Indian settlements but there is no reference of a clock in Akbar's period. The only definite evidence that we get of the clock is in Jahangir's period. The initial response, however, had been disheartening and in 1613, the English company 'resolved' not to send any clocks. Nevertheless, in 1614, Sir Robert Shirley amongst divers toys presented him with 'a standing striking clock of silver which had in it other petty inventions, it is worth some 100 £', which was greatly esteemed by him.\textsuperscript{86} That Jahangir took it as a

\textsuperscript{81} Nicolao Manucci, \textit{Storia Do Mogor}, vol.ii, p.401.
\textsuperscript{82} \textit{EFI}, 1624-29, p.93.
\textsuperscript{83} For such spectacles, see \textit{Bahar-i-Ajam}, s.v. \textit{ainak}.
\textsuperscript{86} Otto Kurz says that the first watches to reach the Mughal court came from Persia when in 1616 Shah 'Abbas sent these clocks, which is wrong as he received clocks even before also. Kurz, Otto
mere novelty is evident from his remark that 'king demanded such things of me for his women to wear in hunting, white or some light colour, for his hunting journeys would be esteemed.' In fact in 1615, the English factors asked for a clock fitted with some rare devices 'to strike after the Moors' fashion,' but it doesn't seem to have worked out. Then, Sir Thomas Roe gave a clock along with two other 'trifles' to him. Jahangir's disinterest in this new device can be judged from the fact that his memoirs do not allude to gifts of clocks and watches either from Europe or Persia.

Even when one Richard Steel, an English adventurer, came to his court with a painter (Hatfield) and a clockmaker with a view to acquiring patronage from the Emperor, and thus 'to earn some


Letters Received, vol.ii, Sept.1614, p.108.

ibid., vol. iii, p. 88.

Firstly, 'because they are quicklie out of frame and none can mend them but clockmakers', secondly, because of the risk of their being damaged during the voyage; and lastly, because it was uncertain how the people in India 'doe accompt their daies.' This perhaps alludes to the different time-measurement system in India from that of Europe. While the Indian system had 60 'hours' of 24 minutes to the full day, the European consisted of 24 hours of 60 minutes. Obviously, European clock would not have served any purpose for Indians unless they adopted the European system of 12 equal double-hours, and modify it to bring the clock in line with the Indian way of measuring time, just like the Chinese did Cf. Sarton, George Introduction to the History of Science, p. 1547. (See Baburnama, tr. A.S. Beveridge, vol.ii, pp. 516-17; Fazl, Abul Ain-i-Akbari,vol.iii, p. 6; Terry, Edward A Voyage to East India, &c., 1616-19, p. 317; John Marshall in India-Notes and Observation in Bengal, p. 281; Thevenot, Jean de The Indian Travels of Thevenot and Careri, pp. 139-40. Also see F. E. Pargiter, 'The Telling of Time in Ancient India', JRAS, 1915, pp. 690-715; Cf. Joseph, Needham Science and Civilization, vol. v, pt ii, p. 439 and n. (c) p. 440 n. (a), p. 461).

profits', he failed in getting Jahangir interested in clockmaking.\textsuperscript{91} The English factors at Balasore asked the Company in 1650 to send four or five good 'substantial house-clocks' to be given as presents to the governors and princes.\textsuperscript{92} In 1666, Tavernier gave a 'watch having a case of enamelled gold' to the 10-year-old son of Sha'ista Khan.\textsuperscript{93} He also presented costly watches to a high Mughal official, and to a eunuch of Princess Jahan Ara Begum.\textsuperscript{94} But there was a similar show of disinterest on their part too. In fact, clocks continued to be procured only as gifts and there is no evidence of the purchase of European clocks by Indians during the seventeenth century.\textsuperscript{95} Tavernier gave two watches as presents to a Mughal noble and a eunuch of Princess Jahan Ara costing 480 and 174 rupees respectively.

It is clear that manufacture of clocks could not have, in any case, been attempted because the two most essential features of an ordinary mechanical clock, that is, the weight-drive and scapesiest were not known in Mughal India.\textsuperscript{96} There is no evidence that the metal was employed in the gear-wheels, (in pre-modern India, two forms of gearing were known; worm-gearing and pin-drum) and, unless this was done, there could hardly be any employment of

\textsuperscript{91} W. Noel Sainsbury (ed.), \textit{Calendar of State Papers}, 1617-21, p. 120. Also see Kurz, Otto \textit{European Clocks and Watches in the Near East}, p. 64.
\textsuperscript{92} \textit{EFI}, 1646-50, p. 338.
\textsuperscript{93} Tavernier, Jean Baptiste \textit{Travels in India}, 1640-67, vol.i, p. 130.
\textsuperscript{94} \textit{ibid.}, p. 140.
\textsuperscript{95} Cf. I.O. Surat G/36/5, f. 42 for the 'chests of clocks'; G/36/94, f. 21 a (these two references relate to a.d. 1697 and 1694). Also see I.O. Surat G/36/9, 27 Feb. 1717. cf. A.J. Qaiser, \textit{Indian Response to European Technology and Culture}, p.69.
\textsuperscript{96} Joseph, Needham \textit{Science and Civilization}, vol. iv, pt ii, p. 441 and n. (c).
sophisticated gearing.\textsuperscript{97} The question of manufacturing
clocks could thus not arise. Forms of gearing after European
examples were thus not adopted in India till well into the 18th
century.

In the armament sector, the earliest source of European
influence during the sixteenth century was the Portuguese. It is fair
to say that while the Portuguese could not have succeeded without
important qualitative military advantages, they were still using
older technology than had been provided during the Artillery
revolution. For example, by the 1440s and 50s ordnance of cast
bronze was edging out wrought iron as the premier European
ordnance. The French ordnance was superior for many reasons: the
guns were cast of high quality bronze and were therefore light for
the weight of ball they fired;\textsuperscript{98} whereas the Portuguese ordnance
was probably mostly of wrought iron. Then, between 1465 and
1477 the gun design in Europe had improved dramatically. It was
discovered, that a small iron cannon ball could do more damage
than the large stone balls (which fractured on impact) could. It was
thus possible to make new guns which were much smaller (6-8 feet
(1.8-2.4 m) long), but more powerful than the old bombards. The
small size allowed the guns to be mounted on wheels, and thus be
mobile. But from what we know of later developments, the largest
Portuguese naval guns must have thrown stone balls of some thirty
to forty pounds. Nevertheless, the Portuguese ordnance was far
more powerful and more effective than that of the Arab and Indian
vessels. Cannons in which gun-powder was used to propel balls of
metal or stone had appeared in Europe and China almost

\textsuperscript{97} J. Ovington, \textit{A Voyage to Surat in the Year 1689}, ed. H.G.
\textsuperscript{98} Duffy, Christopher \textit{Siege Warfare: the Fortress in the Early
simultaneously about the middle of the fourteenth century. The Zamorins of Calicut did have some cannonry, but it was certainly inferior, and those who manned them were adept neither at aiming nor reloading, which suggests that fire arms were not very common there. In 1503, some iron guns were used by his men which could project stones 'as hard as a man could throw them.' Therefore, some efforts were made to acquire European technology in warfare. Varthema has preserved an account of the two Milanese who were weaned away from the Portuguese to manufacture ordnance for the Zamorin.

Handgun was another gift of Artillery Revolution and was developed in 1420s and 1430s. ('Harquebus' or arquebus, was a small portable handgun fitted with a matchlock, The handguns were introduced by Babur in the beginning of the sixteenth century in the form of Turkish matchlocks. (The response of the local troops garrisoning the fort of Bajaur to the use of tufang by Babur's men in 1519 indicates that they were not at all familiar with this new weapon.

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103 Baburnama, tr. by A.S. Beveridge, reprint, London, 1969, p.368). Early handguns of the Ottoman Empire were also called tufang/tufak and banduq. (I.A. Khan, Gunpowder and Firearms-Warfare in Medieval India, p.115) Jos Gommans finds the discussion about the introduction of gunpowder in India, complicated by the ever changing nomenclature of the weaponry involved. The distinction between so-called ‘co-viative’ throwers of projectiles and true guns—i.e. where a bullet or a cannon ball fills the bore of the barrel in order to use the maximum propellant force
The Indian *bundug* ('bonducos') has been identified with arquebuses and similar handguns. Curiously, Abul Fazl compares Mughal technology with Turkey, and not with Europe. Abul Fazl mentions the manufacture of matchlocks, guns and cannons, and bullets etc., but he mentions only Indian gun-makers under Akbar. Handguns were depicted in Mughal paintings also.

of the gunpowder charge—is not always evident from the terminology used in primary sources. This, according to him, is aggravated by the fact that we have only very few Indian sources that are more or less contemporary with the introduction of either gunpowder or guns, and none of these sources refers directly to such an event. Even worse, later sources that describe earlier events, tend to use technical words like *tup* (cannon) and *tufang* (small arms) anachronistically, giving the false impression of an early appearance of these weapons, due to which, he criticizes I.A.Khan, of constructing a tentative argument on the highly circumstantial evidence, that true guns were introduced during the second half of the 15th century, which would be roughly about a half to one century later than the Mameluks and the Ottomans in the Middle East and more or less simultaneous with Iran. For I.A.Khan, the essential reference is found in the word *Kaman-i-rad* (lit. thunder-bow) as used in Persian texts from 15th century Central and South Asia. In his view, these references demonstrate that the Timurids and Bahmanis employed heavy mortars on one occasion capable of throwing a stone projectile of about 12,000 kg. cf. Jos Gommans, *Mughal Warfare: Indian Frontiers and Highroads to Empire 1500-1700*, London, 2002, p.146.

He writes that with the exception of Turkey, probably no other country was equal to the Mughals in this. Fazl, Abul *Ain-i-Akbari*, vol. i, p. 120.

ibid.

ibid., vol. iii, p.121.

ibid.

Nur Jahan with a rifle*, by Abul Hasan, Mughal, probably dated 1612-13-shows her with a long rifle larger than her own size, which must have needed a support to rest and fire, Beach, M.C. *Mughal and Rajput Painting*, CUP, Cambridge, p.96). Portrait of ‘Shahjahan’, by Payag, Mughal, ca. 1630, shows Shahjahan with a hand-gun (and a halo) which is equal his size (*ibid.*, p.145). Another painting shows Shahjahan shooting a Nilgae with a hand-gun (*ibid.*, p.152).
However, during Akbar's period, the latest western advances in firearms would become known in the Mughal empire within a few decades of their first appearance, though the degree of their acceptance varied. The increasing sophistication of the handguns in the West, from simple arquebus of the early period, to the matchlocks, wheel-locks and flint-locks of the 16th-17th centuries meant a manifold increase in the weapon's effectiveness. After the matchlock, whose quality was praised by Abul Fazl, the wheel-lock which first appeared in Europe in the twenties of the sixteenth century was in all probability a familiar firearm in Akbar's personal arsenal by the time Abul Fazl set about collecting information for the A'in-i Akbari (1589). Abul Fazl crediting Akbar with the introduction of a new type of musket in which 'the fire is kindled without fatila [only] with slight movement of masha' most probably indicates a wheel-lock. Latham suggested that it was not a wheel-lock, and perhaps the Mughal arsenal produced what was called a snaphaunce lock—the precursor of the flint-lock on the one hand, and on the other one step ahead of the snapping matchlock. Abul Fazl is silent on the alternative mechanism employed. Latham even says that there is no evidence to establish the introduction of European handguns mounted with wheel-locks into India, though there is also an explicit

110 'Matchlocks are now strong that they do not burst,' Fazl, Abul A'in-i-Akbari, vol. iii, p.121.
111 *ibid.*, 'Wheel-lock was a very delicate and expensive mechanism seldom used for arquebuses and muskets: it was generally used for pistols in Europe. (Cf. Montgomery, Bernard Law *A History of Warfare*, pp. 231-2; also see Daumas, Maurice (ed.) *A History of Technology and Invention*, p. 491.
112 Fazl, Abul A'in-i-Akbari, vol.iii,p.121.
description of a wheel-lock musket penned by an anonymous author in 1630.\textsuperscript{114} At any rate, even if Abul Fazl’s claim is true, such guns were not manufactured on a large scale, and were probably meant for Akbar’s personal use.\textsuperscript{115} Abul Fazl also described a gun, (which could easily be carried by a single elephant; and was) named \textit{Gajnal}. Guns which a single man could carry were called \textit{Narnals}. The \textit{narnal} (used mainly by infantry) was the most popular hand-gun.\textsuperscript{116} It was a matchlock named by Akbar,\textsuperscript{117} and in all probability, \textit{Gajnal} too was a matchlock. In the seventeenth century, \textit{narnal} was developed into a \textit{shaturnal}, which could be handled by a single man.\textsuperscript{118}

In the seventeenth century, we notice a further slackness of response towards European arms technology than had already set in. The arquebuses used by Indians were criticized by European observers.\textsuperscript{119} In 1630s, Indian soldiers ('sipahis') were observed carrying arquebuses which 'being poorly made, and as it were, awkward arms,'\textsuperscript{120} coupled with the inefficiency of soldiers which rendered the arquebuses even more ineffective.\textsuperscript{121} That the wheel-lock (Europe knew the wheel-lock (with pyrites) which began to be used by the 1520s)\textsuperscript{122} had not replaced the matchklock is evident.

\textsuperscript{115} Qaiser, A J. \textit{Indian Response to European Technology and Culture}, p.53.
\textsuperscript{116} For \textit{narnal} see Abul Fazl, \textit{A'\textasciitilde{}in-i Akbari}, vol.i, p.82.
\textsuperscript{117} \textit{ibid.}, vol.i, pp. 119-123.
\textsuperscript{118} I.A. Khan, \textit{Gunpowder and Firearms-Warfare in Medieval India}, p.94.
\textsuperscript{119} \textit{EFI}, 1621-3, P. 72.
\textsuperscript{120} Manrique, Sebastian \textit{Travels, 1629-43}, vol.ii, pp. 125, 227.
\textsuperscript{121} \textit{ibid.}, p. 234.
\textsuperscript{122} Maurice Daumas (ed.), \textit{A History of Technology and Invention}, vol.ii, pp. 488-9.
from the description of a wheel-lock musket by an anonymous author in 1630 which goes to suggest that it was perceived in the Mughal empire down to the beginning of Shahjahan's reign as a very rare and costly firearm. There was, therefore, little question of its being considered for replacing matchlock as the standard firearm in the Mughal army.  

In the beginning of the seventeenth century, flintlock (which began to be used by 1620s) had appeared in Europe. Till 1623, when Pietro Della Valle brought a musket fitted 'with a flintlock after the English fashion' it was quite unfamiliar to the people at Calicut. Possibly, a similar situation existed in the Mughal empire. The description of a musket (chihra-i banduq) in an administrative manual (dastur al 'amal) compiled in 1696 shows, nevertheless that in the second half of the seventeenth century the flintlocks were not only known in the Mughal empire but were, perhaps, sometimes these were also made available to musketeers. But again, these did not replace the matchlock entirely and decisively. Since the Indian muskets in the latter half of seventeenth century were praised for their superior quality iron, but their technology is criticized for not having an efficient trigger and lock. Irvine reached the conclusion that the Mughal musketeers did not manufacture or use the flint-locks, and relied

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121 W. Irvine, The Army of the Indian Moghuls, pp. 105-06
125 Indians make excellent muskets and fowling-pieces. (Bernier, F. Travels in the Mughal Empire, 1656-68, p. 254). This matches Tavernier's statement about Golconda that the barrels of "their muskets are stronger than ours, because Indian iron is 'better and purer' which makes them 'not liable to burst.' Tavernier, Jean Baptiste Travels in India, 1640-67, i. p. 157.
heavily on matchlocks till about the middle of the eighteenth century. However, an account of a riot by artillerymen in 1729, by one Muhammad Bakhsh Ashob suggests that flintlocks were in use by first half of eighteenth century.\textsuperscript{128}

Other skills and concepts coming from Europe around this time were such as marginally improved casting of bronze and brass guns, making it possible to produce heavy mortars as well as light cannons which were more dependable than the earlier ones. These new techniques appear to have been slowly adopted without much difficulty or resistance of any kind. Indians went in for heavy bronze guns which they could cast. But these became obsolete in the seventeenth century. Because of the failure to cast iron, the iron-guns were poorly built, consisting of wrought iron bars and cylinders held together held together by rings.

However, till 1650 European guns cast in iron were not as good in performance as their bronze counterparts.\textsuperscript{129} These being made

\textsuperscript{128} Muhammad Bakhsh Ashob's eye-witness account of a riot by artillerymen in 1729 at the Jami' Masjid in Delhi testifies that the rioters were armed with flintlock (chaqmaq) muskets. (Muhammad Bakhsh Ashob, Tarikh-i Shahadat-i Farrukh Siyar-ba-Julus-i Muhammad Shah (compiled in 1787), vol.i, British Library, Or. 1832, f.61b. Cf. William Irvine, The Army of the Indian Moghuls, p. 106. The relevant line in Ashob's narrative reads: "Companions of Rumi Khan and Saiyad Arab Ali Khan, the officers (minkhashian) of the artillery who were equipped with the instruments of war, picked up flintlock and Ottoman muskets (bandug-ha-i chiqmaqi va Rumi) and European pistols and revolvers, all of which carried belts (tier-hand) containing pellets." Note the bracketing of flintlocks with the Ottoman (Rumi) muskets. Cf. I.A. Khan, The Indian Response to Firearms (1300-1750), p.38n.

\textsuperscript{129} The inability of Indians to copy Europeans cast-iron cannons and adopt more efficient flint-locks as standard military muskets were perhaps the two most conspicuous failures in the field of fire-arms during the 17th century. Khan, I.A. Gunpowder and Firearms-Warfare in Medieval India, p.195.
very heavy were generally regarded as inferior substitutes for the bronze guns. Till then, the only manifest advantage of cast-iron cannon was its relative low cost which was, perhaps, neutralized in India by the option that was always there during the seventeenth century to switch to wrought-iron. Thus it is not surprising that throughout the seventeenth century Indian rulers did not evince much interest in European cast-iron guns. It was mostly the cast-bronze European guns that were coveted by them, although it was realized by the Mughal elite that Indian bronze guns were much inferior to the guns cast in Europe or made by European methods in other parts of the world. Huge bronze mortars were supplemented by light field artillery, cast in brass or made of wrought-iron. Cast-iron was introduced in the mid-eighteenth century. Metallic shot and gun carriages were copied from Europe, but cast-bronze casings round the ends of wrought-iron barrels were a local invention. For muskets, bored barrels, and wheel-lock and flint-lock mechanisms were gradually introduced, involving a mixture of local developments and appropriations from abroad.

The introduction of corned powder at about the same time was intimately bound up in the Artillery Revolution, for corned powder was more powerful – or at least more reliably powerful – than earlier “serpentine,” or dry-compounded, gunpowder. As far as quality of Indian gunpowder is concerned, early in 1616, an English traveller thought that Indian gunpowder was very good.

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130 William Irvine, The Army of Indian Moghuls, p.118; EFI, pp.250; ibid., 1655-60, pp.159-60.
132 Terry, Edward A Voyage to East India, &c., 1616-19, p. 314.
But this opinion is contradicted in 1623 by the English factors at Masulipatam; they stated that though the Dutch made use of some powder for current needs, they essentially relied upon its import from Holland for purposes of storage because, as they point out, 'the other will not keepe, for being ill-corned it growes all into cloodds'. They also added that had it been good, there was no reason why the Dutch should have carried a large quantity of saltpetre home every year from Pulicat.\textsuperscript{133}

The case of matchcords is similar. The European cord was made of hemp or flax 'boiled in old wine dregs or in a solution of wood ash and saltpetre'; if well made, four or five inches of their cord would glow for an hour.\textsuperscript{134} The Indian cord has been best described by Pyrard:

Of the same substance [coconut husk], too, are made matches for arquebuses; it keeps alight well and makes good charcoal, better indeed than ours; but in making matches it is prepared differently from the rope: for the husk or shell must be dried with the fruit, and not plucked green, nor steeped, nor beaten, and the fibre is spun and twisted. When they have made their match, they boil it with ashes. They never cut it, but merely snuff it as it burns away, as we do candles. However, where cotton is common and cocos scarce, they make their matches of cotton.\textsuperscript{135}

As far as we know, no such detailed account is available for the later period, and therefore no inference could be drawn about the interaction between the two types of cords. We can only say that the Indian response may have been indifferent and parallel to

\textsuperscript{133}EFI, 1622-3, p. 336.


\textsuperscript{135}De Laval, Francois Pyrard \textit{The Voyages of Francois Pyrard De Laval}, vol. ii, pt ii, pp. 379-80.
what happened in the case of ropes. We also draw a blank when we turn to look for evidence relating to breech-loading: the Indians continued with muzzle-loading. Generally, the hand-guns were fired like cannon. Fire was put in the priming-pan, and the guns were loaded with muzzle-loading rods.

Another piece of weaponry which came from Europe was the pistol, which seems to have been used in Europe since 1547. The pistol was smaller than the arquebus, and was also different in that it was triggered by a wheel-lock, a very delicate and expensive mechanism. This item does not find a place in the A'in-i-Akbari. As early as 1608, the Portuguese are reported to have carried it to Surat. In 1633, a curious newly invented pistol that served also as a 'walking-staff', was sent from England to the English President at Surat. In 1639, Mandelslo gave a fine pocket-pistol made in London to Mirza Beg, a leading merchant of Cambay. In about the same period, Manrique's pistol was examined by Indian soldiers as something novel. Manucci tells us that a Dutchman presented Prince Dara with a pistol. Again, Tavernier gave a pair of pistols, inlaid with silver, to the ten-year-old son of Sha'ista Khan, the governor of Bengal. He also gave a pair of pocket-pistols decorated with silver to an officer of Mir Jumla in

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136 For a pictorial depiction of muzzle-loading during Jahangir's time, see M.Goedhuis (ed.), *Indian Painting*, Colnoghi, London, 1978, Pl.16: 'Jahangir Hunting Lion from Elephant.'
140 *EFI*, 1630-3, pp. 281-2.
141 S. Commissariat, *Mandelslo's Travels in Western India*, p. 45.
143 Manucci, Niccolao *Storia Do Mogor, 1656-1712*, vol.i, p. 344.
144 Tavernier, Jean Baptiste *Travels in India, 1640-67*, vol.i, p. 130.
Golconda. The English factors in 1683 presented a 'screwed' pistol to Kar Talab Khan, the governor of Surat. These examples suggest that pistols were only bought from Europeans as there is no evidence that Indians manufactured pistols themselves, the main reason being that the Pistols were triggered by a wheel lock and this innovation was not adopted by Mughals, may be because Mughals used artillery mainly against forts and it was of no advantage in assaulting a fort. Irvine's opinion that it was unknown in India before the eighteenth century too is incorrect.

The use of shells, grenades and stink-bombs appears to have caught the eyes of Indians, especially in the latter half of the seventeenth century. Perhaps these items were more useful on the high seas than on land, as we are informed by Manrique that they were 'used by the Portuguese in India in naval engagements, when grappling with the enemy.' While Shah Jahan may not have shown much interest in this branch of artillery, Aurangzeb is reported to have purchased 2,000 shells at 38 rupees per maund in 1658 from the English factors at Surat. Again, in 1666, he bought mortars and grenades from the same source. In the 1680s, grenades and stink-pots were made for the Mughal army in Bengal by a European priest. The use of mortars was learnt from the English deserters by the men of the Siddi of Janjira when he assaulted Bombay. Thus, it is undeniable that the Indians used

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145 ibid., p. 271.
146 EFI, 1678-84, p. 310.
147 He writes that, 'the pistol was in use in India, to some extent, at any rate, early in the eighteenth century.' W. Irvine, The Army of the Indian Mughals, p. iii.
149 EFI, 1646-50, pp. 250, 256.
150 ibid., 1655-60, p. 159.
151 ibid., 1665-7, p. 166.
152 John Burnell, Bombay in the Days of Queen Anne, pp. 143-44.
these new weapons occasionally in different parts of the country at least in the second half of the seventeenth century. But the art of manufacturing them does not seem to have been grasped by Indians; even their use had not become common. Perhaps, as Irfan Habib opines, the reason may have been that the Indian armies possessed an alternative weapon in the ban made of bamboo with iron cylinders containing combustible materials.\(^{153}\)

Another step in the advancement of arms technology in Europe was that towards the end of the seventeenth century the use of a rest was abandoned because the guns had become 'more streamlined, better designed and slightly lighter in weight.'\(^{154}\) In India, the earliest evidence on the use of a rest for handguns comes from the early seventeenth century.\(^{155}\) But the Indian fork was smaller than its European counterpart: the latter was used for firing in a standing position in contrast to the Indian 'squatting' posture.\(^{156}\) Depicting hunting-scenes, some Mughal paintings show

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\(^{153}\) Irfan Habib, *The Technology and Economy of Mughal India,* p. 27. Also *EFI*, 1655-60, p. 279 n.; Bernier, F. *Travels in the Mughal Empire, 1656-68,* p. 48; William Irvine, *The Army of Indian Moghuls,* pp. 147-51.) Abul Fazl also mentions the *ban* (rocket) although these were obviously less effective. *Ain-iAkbari,* vol.i, p. 119, but this is not seen in the miniatures. S.P. Verma, *Art and Material Culture,* p.95.

\(^{154}\) R. Wilkinson Latham, *Antique Guns in Colour,* pp. 22, 25. Earlier, the musket was heavier than the arquebus, and hence it had to be rested on a fork. Also see, Montgomery, Bernard Law *A History of Warfare,* p. 231.

\(^{155}\) Arnold and Wilkinson, *The Library of Chester Beatty,* Pl. 78 (b): 'Jahangir [?] Taking Aim.'

\(^{156}\) Latham, R. Wilkinson *Antique Guns in Colour,* p.24 (sketches). Bernier, F. *Travels in the Mughal Empire, 1656-68* p.217, for 'squatting' position.) Bernier’s account shows the use of wooden forks by Indians in the 1660s. (Bernier, F. *Travels in the Mughal Empire, 1656-68* p. 217. Thevenot, Jean de *The Indian Travels of Thevenot and Careri,* p. 244, where he paraphrases Bernier, and adds that 'they make but ill use of the rests'.).
the long barrel resting on the shoulders of a man, instead of a fork, while the hunter aims at the quarry. In one painting, however, the hunter has been depicted using a rest. It may be pointed out here that the use of a support or rest for heavy guns in India, in fact, predates that for handguns. Musketeers squatted on the ground, resting their muskets on a kind of wooden fork. Perhaps Narnal did not need a fork. A Mughal painting ‘The arrest of Abu’l Ma’ali’, designed by Basawan and painted by Shankar; from an Akbarnama manuscript, Mughal, ca. 1585 shows two men with ‘long-barrelled hand-guns with handles rested on their shoulders’. The gun called the jaza’il, which is being used in a siege, is also shown resting on a tripod. Steingass has described the jaza’il as a large musket, a wall-piece swivel, a rifle used with a prong or rest. The tripod called shakh-i tufang was the part of the equipment of matchlocks. It was made of wood and was fastened with iron chains. The heavy cannon could also be placed at an angle. For this purpose, a triangular wooden stand consisting of a sloping platform was employed.

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158 See Krishnadasa, Rai Mughal Miniatures, Lalit Kala Academy, (Delhi, 1955). Pl. 9.

159 See for example, the Akbarnama illustrations, vol. i. no. 74/117 (Victoria and Albert Museum), cf. A.J.Qaiser, IndianResponse,p.53.

160 B. Narnal had a long barrel mounted on a butt and was fired with the butt resting on the right shoulder. For details, see S.P.Verma, Art and Material Culture, p.94).

161 See for example, the Akbarnama illustrations, vol. i. p.119. This is a long-barrelled gun. It has not been mentioned by Abu’l Fazl.

162 Steingass, Persian-English Dictionary., s.r., jaza’il.

163 Steingass, Persian-English Dictionary., s.r., jaza’il.

164 An-i-Akhari, vol.i, p.120.

165 S.P.Verma, Art and Material Culture, p.94-95.
Indians were also purchasing arms and ammunition from the Europeans. Making wrought-iron barrels for guns, which was, apparently, not practised in India before it was introduced here from Europe in the beginning of the sixteenth century. In 1618 we find the Dutch selling some brass ordnances to the Indian authorities. Around 1644, the English factors at Surat sent one of their ships to Bassein to fetch some great guns made there for a new junk built for the 'princesses accompt' (Princess Jahan Ara?). We have a number of references relating to the period between 1644 and 1660 to the sale of English guns and cannons to Indians. Later in 1666, the English factors struck a deal with Aurangzeb to sell him several large brass guns, besides mortars and shells.

Not only were the Europeans employed in army, they were also engaged in manufacture of arms, which depicts another aspect of their perception of Europeans as being adept in making armament, although significantly, almost all our relevant information comes from the second half of the seventeenth century. Mir Jumla is reported to have had in his service a certain Maille,

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166 Travels of Ludovico di Varthema, 1503-1508, tr. J.W. Jones and G.P. Badger, London, 1863, pp.262, where there is a reference to a Jew among the Portuguese renegades making four mortars of iron at Calicut.
167 EFI, 1618-21, p. 92, n. 2. 250.
168 EFI, 1642-5. p. 148.
169 ibid., 1646-50, pp. 166, 213, 250. 254, 257; 1655-60, pp. 10, 12, 166, 169, 212, 264 and n. i.
170 ibid.1665-7, PP. 155-56. Apart from guns, shot also was procured from the English by the Surat authorities 'cf. EF, 1618-21. p. 238. Shot was made by the English in large quantities at Surat in 1625 ;cf. ibid., pp. 73. 85.
from Amsterdam, to establish gun foundries.\textsuperscript{171} In 1663, he employed Thomas Pratt, an Englishman, to build boats and manufacture ammunition in Bengal.\textsuperscript{172} In 1666, Aurangzeb asked the English factors to send him 'five gun-founders and two engineers or pioneers.'\textsuperscript{173} More definite evidence comes from the last decade of the seventeenth century in Bengal where, we are told, a priest of the Augustine order had established an armoury for the Mughal army with enough weapons to arm six hundred men. The armoury consisted of 'carbine, bayonet and granado', besides a vast number of stink-pots being supplied from the four or five forges in his yard, so that he hath in a manner quite turned the Church into an arsenal.\textsuperscript{174}

The relative lack of dexterity of Mughal soldiers even in the use of fire-arms is an indicator of acceptance of European soldiers' superior handling skills, as far as fire-arms were concerned, till almost the end of the seventeenth century. Speaking of the Mughal army, Bernier refers to 'the artillerymen who receive great pay, particularly all the Franguis or Christians-Portuguese, English, Dutch, German, and French; fugitives from Goa, and from the Dutch and English Companies.'\textsuperscript{175} Careri describes his meetings with Europeans, especially the French, in the 'Christian Gunner's

\textsuperscript{171}Tavernier, Jean Baptiste \textit{Travels in India, 1640-67}, vol. ii, pp. 289-90.
\textsuperscript{172} Manucci, Niccolao \textit{Storia Do Mogor, 1656-1712}, vol. ii. p. 87; \textit{EFI}, 1660-4, p. 294. Pratt also made swivel guns.
\textsuperscript{173} \textit{EFI}, 1665-7, p.185.
\textsuperscript{174} Burnell, John \textit{Bombay in the Days of Queen Anne}, pp. 143-4.
\textsuperscript{175} Bernier, F. \textit{Travels in the Mughal Empire, 1656-68}, p. 217; also Careri in the \textit{Indian Travels of Thevenot and Careri}, tr. and ed. S. N. Sen, p. 244.
Quarter in Aurangzeb's camp. Mir Jumla is reported to have taken the fort of Gandikot with the help of French, English, Dutch and Italian gunners. When Manucci learnt that Prince Dara wished to employ him, he rejoiced at the news because he was told that 'Europeans who served this prince had a good life and received adequate pay.' The men of the Siddi of Janjira, who attacked the Bombay fort with devastating effect, were alleged to have been taught the 'art of mineing, and sheltering themselves in their trenches and Basket-works' by deserters from the English forces. A European eye-witness states that they learnt the use of mortars also from the same source. Later, the witness himself accepted employment in Bengal as a 'commander of 100 European soldiers' in the Mughal army. Prince Murad Bakhsh enlisted the help of Dutch miners to blow up the walls of Surat fort.

The purpose of these selected examples is to give an idea of the widespread practice of employing Europeans in artillery. Their presence in the army was crucial in determining the course of an expedition or conquest. It is owing to their qualitative significance that Prince Dara on one occasion to have deprived Mir Jumla of the eighty European artillerymen in his service through bribery. Sha'ista Khan did the same to win over European naval officers of

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176 Careri in *Indian Travels of Thevenot and Careri*, pp. 217, 218. Also see Tavernier, Jean Baptiste *Travels in India, 1640-67*, vol. i, p. 59.
177 Tavernier, Jean Baptiste *Travels in India, 1640-67*, vol. i, p. 284, 288.
178 Manucci, Niccolao *Storia Do Mogor, 1656-1712*, vol. i, pp. 93, 95.
179 Ovington, John *A Voyage to Surat in the year 1689*, p. 94.
180 Burnell, John *Bombay in the Days of Queen Anne*, p. 19.
181 *ibid.*, pp.140-1.
182 Bernier, F. *Travels in the Mughal Empire, 1656-68*, p. 31.
the King of Arakan. It is natural for us to expect that exposure to European gunners and sappers over such a long period must have imparted considerable skill to their Indian counterparts. Perhaps the exact degree of skill so acquired by the Indians cannot be gauged; nevertheless, some indications are available. Bernier remarks:

Formerly, when the Moguls were little skilled in the management of artillery, the pay of the Europeans was rather liberal, and there are still some remaining who receive two hundred roupies a month; but now the King admits them with difficulty into service, and limits their pay to thirty-two roupies. The reduction in salary is corroborated by Fryer who notes: ‘formerly for good pay, now very ordinary, having not above 30 or 40 rupees a month.' Later, Careri paraphrases Bernier, and then adds: ‘Some of them formerly had 200 roupies a Month, but now the Moghuls have learnt somewhat of the Art they have less.' Thus, the scaling down of Europeans’ salary in Mughal service has been ascribed by Bernier and Careri to the declining dependence of Indians on their skills, Indians having somewhat improved their own. However, European artillerymen continued to be employed in Mughal army. As Manucci observed, European artillerymen in Mughal service 'had only to take aim; as for the rest—the fatigue of raising, lowering, loading, and firing—this was the business of artificers or labourers kept for the purpose.' In 1666, the English factors doubted that Aurangzeb's Indian soldiers could handle cannons and mortars on their own. The case with 'light' guns was similar.

185 Bernier, F. Travels in the Mughal Empire, 1656-68, p. 217.
187 Careri in Indian Travels of Thevenot and Careri, p. 244.
189 EFI, 1665-7, p. 66.
So far as swords are concerned, the European accounts show Indian preference for crooked swords in contrast to the straight ones in general use in Europe along with other types. That is why it was noted in 1614 that 'streight swordes' could not be sold at Surat.\textsuperscript{190} The English factors asked their Company early in the seventeenth century to send one or two thousand crooked swordblades 'of this country fashion' for sale and presents.\textsuperscript{191} Terry in 1612 noticed that the Indian 'curved swords were very sharp, but for want of skill in those that temper them, will break rather than bend.'\textsuperscript{192} Indians wanted swords with a better quality of metal so that they did not break when bent.\textsuperscript{193} To meet this demand, the English furnished them with English swords at high prices that will bow and become streight againe.\textsuperscript{194} In the 1660s, Thevenot tells us that 'the swords made by the Indians are very brittle', and consequently the English brought 'good ones' from England.\textsuperscript{195} The Indian curved sword did not however prevent its wielder from showing dexterity in battle. Olafsson is quite sure that Indians are 'surprisingly skilful in the use of arms, both with swords with curved blades.'\textsuperscript{196} One weakness of the curved sword is, however, recorded by Fryer. When asked to explain the utility of a European rapier in actual battle, he said that since the European custom in

\textsuperscript{190} Farewell's account in \textit{The Voyage of Nicholas Downton to the East Indies, 1614-15}, Hakluyt Society, (London, 1939), p. 165.

\textsuperscript{191} \textit{Letters Received}, vol.i, p. 239; ii, p. 301.

\textsuperscript{192} Terry, Edward \textit{A Voyage to East India, &c., 1616-19}, in William Foster (ed.) \textit{in Early Travels in India 1583-1619}, Reprint, (Delhi, 1968), p. 314.

\textsuperscript{193} \textit{Letters Received}, vol.iii, p. 9.

\textsuperscript{194} Terry, Edward \textit{A Voyage to East India, &c., 1616-19}, p. 314.

\textsuperscript{195} Thevenot, Jean de \textit{The Indian Travels of Thevenot and Careri}, p. 61.

\textsuperscript{196} \textit{The Life of Icelander Jon Olafsson}, tr. D.B. Phillpotts, Hakluyt Society, 2\textsuperscript{nd} Series, (London, 1931), vol.ii, p.145.
war was to appear 'all armed, the Indian sword might not be of much use whereas the 'sharp-appointed weapons would pierce the junctures of the Harness, or the pleats of a coat of Mail.'\textsuperscript{197} Again, Tavernier stated that the European method of point-fence was unknown to Indians.\textsuperscript{198} The swords in the Akbarnama illustration are curved swords, effective only for slashing from horseback. The curved sword appears in many depictions of the Mughal emperor, even when he was at leisure in his harem. A hunting scene\textsuperscript{199} shows Akbar and his attendants on horseback with bow-arrow and curved sword.\textsuperscript{200} ‘The arrest of Abu'l Ma'ali,’ designed by Basawan and painted by Shankar, from an Akbarnama manuscript, Mughal, ca. 1585 shows two men with ‘straight’ swords and two men with long-barrelled hand-guns with handles rested on their shoulders.\textsuperscript{201} Akbar reportedly was fond of carrying a European sword and dagger.\textsuperscript{202}

Coal had been discovered in Europe as a new source of heating, and it was used for a few selected purposes during the sixteenth and seventeenth centuries.\textsuperscript{203} ‘Sea-coal’ as a new source of fuel, are first mentioned in 1612-13 when these were brought to Surat by the English and were carried ‘for a wonder to the Mogul’ (Jahangir). Nothing is known of Indian response to this

\textsuperscript{197} John Fryer, \textit{A New Account of East India and Persia being Nine Years' Travels, 1672-81}, vol.i, p. 336.
\textsuperscript{199} ‘Prince Akbar hunting a nilgai,’ from the Fitzwilliam Album, probably at Delhi, ca. 1555-1560.
\textsuperscript{201} \textit{ibid.} p.65.
new fuel.\textsuperscript{204} Although, at this time, Europeans did not use coal in a way that confirmed its utility in the eyes of Indians, nor did they take to coal mining in India, which started only from 1774.

The printing of paper had evolved in various stages across the centuries and across the continents. In the sixteenth century, the developed technique of printing press (in the twelfth century. papermaking technology from China reached Spain through Arabs. Chinese technique of wooden-block printing was transferred to West between 1250 and 1350) was brought to India when European movable metal types\textsuperscript{205} were brought to Goa around 1550 by the Portuguese, and in 1556 a Portuguese missionary, Juan de Bustamante, started operating it.\textsuperscript{206} Printing Press, when introduced in India by the Europeans, was not adopted by the Mughal rulers. Abul Fazl\textsuperscript{207} makes no mention of the Printing Press while dealing with the art of writing. Although Abul Fazl did realize he importance of the written word, as he says that ‘if it was not for the letter, the spoken word would soon die, and no keepsake would be left us of those that are gone by,’\textsuperscript{208} he lent no support to the printed word. The Mughals did have several opportunities of coming into contact with printed materials from

\textsuperscript{204} The Rev. Patrick Copland's narrative in ‘The Voyage of Thomas Best, ed. W. Foster, Hakluyt Society, 2\textsuperscript{nd} Series, London, 1934, p. 208.
\textsuperscript{205} For the development of printing in Europe, see S. H. Steinberg, \textit{Five Hundred Years of Printing}, 3rd ed., Suffolk, 1977.
\textsuperscript{207} \textit{Ain-i-Akbari}, tr.p.103,113.
\textsuperscript{208} \textit{ibid.}, p.103.
Europe. The first Jesuit mission to Akbar in 1580 presented him with seven volumes—out of eight—of Plantin's polyglot Bible printed in five languages—Hebrew, Greek, Aramaic, Latin and Syriac. Akbar had acquired a large number of printed books from Europe which were lodged in the imperial library for fifteen years when, in 1595, he gave away a few of them to the third Jesuit mission, along with the volumes of the polyglot Bible. Although we do not have any record of the response at Akbar's court to the art of printing, it is obvious that it was not encouraging. It did not arise any curiosity even in Fathullah Shirazi, the scientist at the court who served Akbar from 1583 to 1588.

Even 'Abd'ul Sattar, an eminent scholar, whom Akbar had commissioned to study the language of the Frangis' and who is reported to have studied under the guidance of Father Xavier and later collaborated with him in translating his Latin work into Persian (subsequently printed in Europe and distributed in India), did not show any interest in this new technology.

Jahangir did take some limited interest, however. In 1606, at Lahore, the Emperor is reported to have expressed doubts about types being cast in the Persian script during a discussion with the Jesuits, whereupon the latter promptly dispelled them by showing him their copy of the Arabic version of the Gospels which they had

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obtained from an Italian in 1604 at Agra.\textsuperscript{214} This was probably one of the copies printed in 1591 at the Vatican.\textsuperscript{215} But Jahangir's interest evaporated quickly since we do not hear of this topic being raised again. The Portuguese presented a printing press to Jahangir but he showed no interest in their gift.

From the early period of Shahjahan's reign onwards, there were some printed books in both Arabic and Persian scripts in circulation. For example, Father Jerome Xavier's works in Persian were published in 1638 and 1639. A book in Arabic published in 1649 on theological refutation of some Islamic work was distributed in India. When it was brought for propaganda to the court of Shah Jahan in 1651, his Wazir, Sa'dullah Khan, refused to accept it.\textsuperscript{216} In 1674-5, a printing press at Bombay was imported from England by the English Company but it was not on the request of any Mughal official but on request of a merchant named Bhimji Parak.\textsuperscript{217}

It is therefore hardly surprising that none of the European nations, except the Portuguese, established a press in India during this period. Even as late as in 1689, a European noticed the absence of printing among Indians, which shows that printing was not adopted by Mughals even by the end of the seventeenth century.\textsuperscript{218}

While the disinterest of the ulema and service class may be

\textsuperscript{214} ibid., pp. 211,215.
\textsuperscript{216} E. Maclagan, \textit{The Jesuits and the Great Mogul}, pp. 208-9.
\textsuperscript{218} He sought to explain it as follows: 'Neither have they endeavour'd to transcribe our Art of Printing; that would diminish the Repute and Livelihood of their Scrivans, who maintain numerous families by the pen.' (Ovington, John \textit{A Voyage to Surat in the year 1689}, p. 149)
explained in the terms of their apprehension regarding the low-borns acquiring knowledge through better availability of books by means of printing, the callousness shown by the elite was not simply their fetish for calligraphy, but a socio-cultural set-up which did not require large scale circulation of books which should have needed printing.

Abul Fazl, while writing about horticulture, does not mention any European contribution to it. The first reference that we get of grafting technique in horticulture, which was introduced by Portuguese, is from Jahangir’s time. One of his nobles, Muqarrab Khan’s famous gardens at Kairana where he planted fruits, especially mangoes, had fruits also from Europe (Firang). Unfortunately we do not know about the varieties of mangoes or other fruits that he planted, nor whether he made use of grafting techniques, through which the Portuguese had produced for him the first grafted mango, the Alfonso. Jahangir in his memoirs states that the pine-apples at his time came from the harbour towns held by the Portuguese.

Tobacco and the huqqa were introduced in the court of Akbar early in the seventeenth century, and thenceforth, smoking became extremely widespread in India. The Mughal elite used glass and jade huqqa bowls. Some of such huqqas of the late seventeenth century have been listed by Ashton. Mughal elite

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220 ibid. p.93-94.
221 Tizuk-i Jahangiri, ed. Sayyid Ahmad, p. 3.
222 Asad Beg, Ahwal-i Asad Beg Qazwini, MS. BM. OR. 1996 (Rotograph in Department of History, Aligarh Muslim University), ff. 36-37.
mainly procured hubble-bubbles either in gift or by purchase. We only find evidence of its small scale manufacture in some parts of Bihar in the latter half of the seventeenth century. John Marshall (1670), for example, speaks of the manufacture of 'neat hubble-bubbles' at Bhagalpur in Bihar, although he leaves it uncertain whether the bowls were made of glass or the coconut. However, it seems that the hubble-bubbles of European make were still held in esteem as we get a reference where the governor of Surat in 1697 even forced the English factors to sell him twenty-two glass hubble-bubbles (which were meant for Agha 'Peeree', a merchant, as the former wanted to resell them in the town to his profit). It was as late as in 1748 that a Persian glossary compiled in the said year notes that Azimabad (Patna) produced the finest glassware including (glass) hubble-bubbles (galian) which were taken by merchants to other towns. But it cannot be determined whether the technique of making glass bowls was learnt under Persian or European influence, since even those of Persian make came mostly through the European agency.

The art of Diamond polishing was criticized by the European travelers in the seventeenth century. Fryer commented that diamonds cut by the Indians fell short of the Fringies in Fancy, and that is why they were sold mostly in India; to Europe the diamonds were exported uncut and cut 'to more advantage.' Tavernier, the European expert in precious stones and diamonds, firmly opines;

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'The Indians are unable to give the stones so lively a polish as we give them in Europe.' It was for this reason that European jewelers were accorded a warm reception in India. As early as 1584, William Leeds, an English gem-expert, accepted service under Akbar. Jahangir mentions a European jeweller under his employment on whom he bestowed the title 'hunarmand.' When Mir Jumla gave Aurangzeb a large uncut diamond, it was returned to him so that he could have it cut by an expert. Among the accounts of Tavernier, Fryer and Thevenot, only the first has attempted to find out the reasons for the inferior quality of the diamonds cut and polished in India. Explaining the inability of Indians to impart a polish comparable to diamonds polished in Europe, Tavernier says:

'this, I believe is due to the fact that their wheel does not run so smoothly as ours. For, being made of steel, in order to grind it on the emery, of which it has heed every twenty four hours, it has to be taken off the tree, and it cannot be replaced so as to run as evenly as it should so. If they possessed the iron wheel as we do, for which one does not require emery but the file, it not being necessary to remove it from the tree is order to file it, they could give the stones a better polish than they do, it is desirable that it should be done every twelve hours.' Besides, Tavernier was of the opinion that the process of 'weighting' the stone which could cause flaws was not current in Europe; but he keenly notes that this

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228 Tavernier, Jean Baptiste Travels in India, 1640-67, vol. ii, p. 58.
process did not produce flaws when practised in India because the wooden wheel, which caused the steel one to revolve, did not run as fast as theirs in Europe because its motion was slowed down, first, by incessantly anointing it with oil and sprinkling it with powder; and secondly, the wooden wheel was not more than three feet in diameter while the European one was bigger. On the other hand, he appreciates the skill of Indians in cutting the 'knots' in a stone, which, as he says, 'our diamond-cutters in Europe would experience great difficulty in doing, and as a general rule would be unwilling to undertake it.'\textsuperscript{234} Again, in another context, we are told that the Indian miners strike blows at the diamond-bearing rocks with a heavy iron crowbar which sometimes fracture the diamonds; but this rough handling was duly compensated by cleaving the stone along the fracture-line in a way better than that in Europe.\textsuperscript{235} European lapidaries in India, especially those who were employed by the rulers or nobles, must have used their own devices for diamond-cutting and polishing. But evidence is not forthcoming to identify Mughal response in this area. Most probably Indian experts continued with their traditional tools and methods: for the cutting of sapphires and diamonds, Thevenot observes: 'They cut Saphirs with a Bow of wire; whilst one workman handles the Bow, another poures continually upon the stone very liquid solution of the powder of white Emrod [emery stone] made in water; and so they easily compass their work.'\textsuperscript{236} The use of the 'bow of wire' is corroborated by a rare Mughal painting, although it does not depict Thevenot's 'other' workman

\textsuperscript{234} ibid., p. 58-9.
\textsuperscript{235} ibid., p. 56.
\textsuperscript{236} Thevenot, Jean de \textit{The Indian Travels of Thevenot and Careri}, p. 138.
who poured the liquid solution of emery upon the stone. It is clear that the Mughal king or elite did not show interest in the difference of technology involved. There is no evidence to show that even the gearing was improved.

The Mughal response to European science and technology was an ambiguous one, and while certain European technological development were treated with indifference, even disdain, there were others that were more readily accepted. One of the things which determined the Mughal response was ‘utility,’ but this ‘utility’ or need was not that of the common subjects, but the rulers and the ruling aristocracy. At the same time, a utility-based interpretation of the Mughal response to European technology is inadequate, for in several instances, resistance to European technology emerged from social and cultural factors, as well.

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237 Hajek, Luber Indian Miniatures of the Moghul School, (London, 1960), Pl. 16. For the earliest pictorial depiction of the bow-drill, see Miftah-ul Fuzala’, f. 161 b. For the use of another device, that is, belt-drive, see John Fryer, A New Account of East India and Persia being Nine Years’ Travels, 1672-81, vol.1, p. 285. There is no evidence that Indians adopted this from Europe.